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DEVICE BY TOOLS FOR SETTING OF A PRODUCTION PACKER.

The invention relates to a device by a tool for the setting of an inflatable packer in an annulus in a well for the extraction of hydrocarbons, in which the annulus is formed between the wall of the well bore and a pipe string, e.g. tubing, which is introduced into a well.

By open hole completion of production wells for hydrocarbons, without the use of cementation and perforated casing, a satisfactory zone isolation of the well is necessary in many cases. The reason for this is that the fluid should be prevented from flowing in an uncontrolled manner in the annulus between the well bore wall and the pipe string. Said zone isolation makes it possible to prevent such uncontrolled flow in the annulus. Thereby it will be possible to control the entering of fluid into the well form the different layers of the ground formation.

Present technique for zone isolation in open well completion, is based on the use of hydraulically inflatable packers or bellows which are set at selected points within the well.

These packers may be inflated by means of for example well fluid. Additionally, there has been developed a system for zone isolation by the use of rubber elements which are compressed mechanically and are forced into sealing abutment against the wall of the well bore.

However, practice shows that the setting of inflatable packers, especially in horizontal wells, is often very problematic. The main reason is that a relatively high setting pressure must be used to operate the valves included in the setting tool. Additionally, the setting pressure will subject the packer to a correspondingly high load. It is not uncommon for the well to obtain an oval cross-sectional shape in the drilling, especially in the drilling of horizontal wells. Said oval cross-sectional shape causes the expansion of the packer to vary along the circumference. The varying expansion of the packer together with said high setting pressure give rise to great loads which at worst may make the packer burst. To ensure a greater stability of the inflated packer over time, it is known for the packer to be filled with cement. The drawback is that such cementation requires a special tool, and additionally it may lead to the risk of cement leakages at undesirable points within the well. Moreover, the cement shrinks when curing, so that the surface pressure between the packer and the wall of the well bore is reduced, or even ceases completely. By the use of packers which are compressed mechanically, only small deviations in the hole geometry are allowed. This involves that such packers do not provide adequate sealing of the annulus of the well. Beyond that, experience data from the North Sea shows that by zone isolation of horizontal wells, more than half the packers do not work satisfactorily.

The main object of the present invention is to provide a device by a tool with an inflatable packer element arranged thereto, which is inflated by means of a hardenable sealing substance, e.g. a two-component thermosetting plastic, to seal the annulus. Other objects are that the packer element is to be inflated by means of a pressure more moderate than what has been common so far. Further, thermal shrinkage of the hardenable sealing substance shall be compensated for, so that the surface pressure of the packer element against the wall of the well bore is maintained in the curing. Thereby the above defects and drawbacks of the known technique can be remedied. As appears from the characterizing part of the present independent claim, this is realized in the way that the tool comprises a sleeve element, three housing elements positioned externally on the sleeve element, and a packer element extending between two of the housing elements, said two housing elements being fixedly arranged on the sleeve element. Further, the third housing element is arranged so, that a hardenable substance is transferred from the housing element to an annulus of the tool between the sleeve element and the packer element, so that the packer element is inflated into sealing abutment against the wall of the well bore when, e.g., well fluid from the pipe string is supplied to the housing element at the same time. The third housing element is formed with several chambers for the hardenable sealing substance and a chamber for the well fluid supplied from the pipe string. This results in the packer element being inflated into sealing abutment against the wall of the well bore by a lower pressure than the pressure of the well fluid supplied to the housing element. Other advantageous features of the invention will appear from the dependent claims and the rest of the specification.

In the following part of the specification and with reference to the set of figures, embodiments of the invention will be explained, wherein

Fig. 1 shows a schematic view of a tool with an inflatable packer element arranged thereto for the sealing of an annulus in a hydrocarbon production well. The annulus is formed between the bore wall of the well and a pipe string which is lowered into the well, and the tool is included as part of the pipe string. A section has been made in the right-hand part of the tool, so that the structural configuration of the tool is shown. The tool is shown in a position prior to the inflating of the packer element into sealing abutment against the wall of the well bore.;

Fig. 2 shows the same schematic view, except that the tool is activated for to inflate the packer element by means of a releasable and displaceable housing element which is displaced up along a sleeve element of the tool. Thereby hardenable sealing substance is transferred from two chambers of the releasable and displaceable housing element into an annular chamber of the tool by the packer element;

Fig. 3 shows the same schematic view, except that the releasable and displaceable housing element has been displaced into an end position in which the transfer of the hardenable sealing substance has ended, and the packer element is fully inflated. In addition, the hardenable substance has charged an accumulator positioned in a lower housing element fixedly arranged on the sleeve element;

Fig. 4 shows the same schematic view, except that the accumulator is in an uncharged position, so that it has

compensated for the curing shrinkage of the hardenable sealing substance, and thereby maintained the surface pressure of the packer element against the wall of the well bore;

Fig. 5 shows a schematic section of an embodiment of the invention, in which said releasable and displaceable housing element is replaced by a housing element which is fixedly arranged on the sleeve element and has an annular piston arranged thereto. Otherwise, the tool has the same structural configuration as shown in Figs. 1-4, and it is shown in a position prior to the inflation of the packer element into sealing abutment against the wall of the well bore;

Fig. 6 shows the same schematic section as the one shown in Fig. 5, except that the tool is activated to inflate the packer element;

Fig. 7 shows a schematic section of an embodiment of the invention, in which the lower end of the packer element is connected to an upper releasable and slidable housing sleeve element which is arranged externally on the lower fixed housing element. Otherwise, the tool has the same structural configuration as shown in Figs. 1-6, and it is shown in a position prior to the expansion of the packer element into sealing abutment against the wall of the well bore; and

Fig. 8 shows the same schematic section as the one shown in Fig. 7, except that the tool is activated to inflate the packer element.

In the set of figures the present tool, with the inflatable packer element 8 arranged thereto, is shown as a component of

a pipe string 3, e.g. a production pipe, extending down into a well for the recovery of hydrocarbons. This may be done in the way that either end of an inner sleeve element 4 of the tool is secured to the respective end of adjacent parts of the pipe string 3, e.g. by means of threaded connections, not shown. Alternatively the sleeve element 4 may be secured in a suitable manner externally on a pipe string 3 extending therethrough. Said inflatable packer element 8 may be used in the zone isolating or other sealing of the well, so that it is prevented, for instance, that fluid passes in an uncontrolled manner in an annulus 2 between the pipe string 3 and the bore wall 1 of the well. The packer element 8 is inflated by means of a hardenable sealing substance, e.g. a two-component thermosetting plastic, which is transferred from a housing element 7; 30 to an annular chamber 9 of the tool, when at the same time, well fluid, for example, is supplied from the pipe string 3 into the housing element 7; 30. The pipe string 3 is equipped with the number of tools which is required for zone isolation of the well in question.

According to the embodiment shown in Figs. 1-4, the tool comprises three housing elements 5, 6, 7 positioned externally on the inner sleeve element 4, and a packer element 8 extending between two of the housing element 5, 6. The two housing elements 5, 6 first mentioned, are fixedly arranged, and the third housing element 7 is releasably and displaceably arranged on the sleeve element 4. Said releasable and displaceable housing element 7 is secured to the sleeve element 4 by means of not shown securing means, e.g. shear pins. One end of the packer element 8 is fixedly connected to the fixed housing element 5 located the most distant from the releasable and displaceable housing element 7, and the opposite end of the packer element 8 is fixed to a

packer sleeve element 26. The packer sleeve element 26 is releasably and slidably arranged on that side of the intermediate fixed housing element 6, which faces inwards towards the sleeve element 4. The packer sleeve element 26 is releasably arranged by means of not shown shear screws or corresponding elements. The shear screws break by a predetermined stretching of the packer element 8. Thereby is avoided that the packer element 8 is stretched between the fixed housing elements 5, 6 during inflation.

The releasable and displaceable housing element 7 is formed with at least three flanges 13, 14, 15, directed inwards towards, and adapted to rest slidingly on, the sleeve element 4. Further the sleeve element 4 is formed with at least two flanges 16, 17 directed outwards towards, and adapted to rest slidingly on, said housing element 7. The housing element flanges 13, 14, 15 and the sleeve element flanges 16, 17 are positioned alternatingly one behind the other, so that they form separate chambers 10, 11, 12 between themselves inside the releasable and displaceable housing element 7. The housing element chambers 10, 11 accommodate the hardenable sealing substance which is transferred to the annular chamber 9, and the housing element chamber 12 is to accommodate fluid, e.g. well fluid, supplied from the pipe string 3 when the packer element 8 is inflated. The hardenable sealing substance is in fluid form while in the housing element chambers 10, 11. The well fluid is supplied through at least one passage 13 formed in the sleeve element 4 by the housing element chamber 12. Said passage 13 is equipped with suitable valve equipment.

The releasable and displaceable housing element 7 is arranged so, that it can be released from and displaced along the

sleeve element 4, when the packer element 8 is to be inflated into sealing abutment against the wall 1 of the well bore. The releasing and displacing takes place by means of well fluid supplied to the housing element chamber 12 from the pipe string 3. Thereby, the well fluid will press against the housing element flange 15, so that the not shown shear pins break at a predetermined pressure from the well fluid on the housing element flange 15. The releasable and displaceable housing element 7 is then displaced along the sleeve element 4. In the displacement the housing element flanges 13, 14 will be displaced towards the pipe string flanges 6, 17. This involves that, at the same time, the hardenable sealing substance is pressed out of the housing element chambers 10, 11 when the volumes thereof are reduced by the displacing of the releasable and displaceable housing element 7. In the displacing, the well fluid will press against the housing element flange 15, so that the housing element chamber 12 works as a pull cylinder with a piston area corresponding to said housing element flange 15, and with the housing element chambers 10, 11 as connected push cylinders for the hardenable sealing substance, with a piston area corresponding to the housing element flanges 13, 14. Relative to the pressure from the well fluid supplied in the housing element chamber 12, a reduced pressure is thereby achieved in the hardenable sealing substance, which is transferred from the releasable and displaceable housing element 7, according to the ratio of the piston areas.

The hardenable sealing substance is transferred from the housing element chambers 10, 11 to an annular chamber 9 of the tool behind the packer element 8. This is implemented by means 19, 20 for the transfer of the hardenable sealing substance, and an associated valve unit 21. Said means 19, 20

is arranged in the releasable and displaceable housing element 7, and is constituted by e.g. thin pipe elements 19, 20 extending from the respective housing element chambers 10, 11 through the respective housing element flanges 13, 14, pipe string flange 16 and an upper flange 22 of the intermediate fixed housing element 6, so that hardenable sealing substance may be transferred to the annular chamber 9 behind the packer element 8. The valve unit 21 is positioned on that side of said upper housing element flange 22, which faces inwards towards the annular chamber 9, and opens as a consequence of hardenable sealing substance being pressed out of the housing element chambers 10, 11. To retain the hardenable sealing substance within the annular chamber 9, the valve unit 21 is formed as a check valve unit. By preference the non-return effect becomes effective only when the releasable and displaceable housing element 7 has made the full length of its displacement, and the housing elements 10, 11 have been essentially emptied of the hardenable sealing substance, so that the housing element chambers 10, 11 are not influenced by pressure from the well fluid. The components of the hardenable sealing substance are mixed by means of at least one mixing pipe 27, positioned on that side of the packer sleeve element 26, which faces inwards towards the sleeve element 4.

In the type of thermosetting plastic used to inflate the packer element 8, a great deal of the shrinking takes place while the thermosetting plastic is still in fluid form. To compensate for the reduction in volume of the thermosetting plastic, due to said shrinkage, the tool is provided with an accumulator 23, 24, which is adapted so, that the surface pressure of the packer element 8 against the wall 1 of the well bore, is essentially maintained when the hardenable

substance shrinks. The accumulator 23, 24 is charged by means of the hardenable sealing substance supplied during inflation of the packer element 8. The accumulator is formed of a compressible compression spring 23 positioned in an annular chamber 25 between the fixed housing element 5 which is the most distant from the releasable and displaceable housing element 7 and the sleeve element 4, and an associated displaceable flange arranged to rest glidingly on the fixed housing element 5 and the sleeve element 4.

In Figs. 5-6 another embodiment of the invention is shown. The difference between the embodiments consist in the fact that the third housing element 30 is fixedly arranged on the housing element 4 and, moreover, has a displaceable annular piston 31 arranged thereto. Otherwise, the tool has a structural configuration and operation corresponding entirely to that of the tool mentioned above. The annular piston 31 is arranged so, that the hardenable sealing substance is transferred from the housing element 30 to the annular chamber 9, when the annular piston 31 is displaced, at the same time, along the sleeve element 4 by means of the well fluid supplied. The fixed housing element 30 is provided with at least three flanges 35, 36, 37 fixedly arranged on the sleeve element 4, and the annular piston 31 is provided with at least two flanges 38, 39 adapted to rest slidingly on the fixed housing element 30 and the sleeve element 4. The flanges 38, 39 of the annular piston is positioned on either side of the middle housing element flange 36, so that the flanges 35, 36, 37, 38, 39 of the housing element and the annular piston form, between themselves, separate housing element chambers 32, 33 for the hardenable sealing substance which is transferred when the packer element 8 is to be inflated, and a housing element chamber 34 for the well

fluid, which is supplied to displace the annular piston 31 along the sleeve element 4. The housing element 30 is formed with at least one vent 40 at the lower housing element flange 35.

In Figs. 7-8 is shown an alternative configuration of the fixed housing element 50, 51 the most distant from the releasable and displaceable housing element 7 or the fixed housing element 30 with the annular piston 31. Thereby further security can be provided against stretching of the packer element between the fixed housing element 50, 51 and the packer sleeve element 26, during inflation. Here, the housing element is formed by a lower housing element 50, which is fixedly arranged on the sleeve element 4, and an upper housing sleeve element 51, which is releasably and glidably arranged externally on the lower housing element 50. The sleeve element 4 is provided with a number of support elements 53, each with an associated locking pin 54. The locking pins 54 are adapted to rest releasably in a groove 55 formed in the housing sleeve element 51, so that the housing sleeve element 51 is retained until the tool is activated to inflate the packer element 8. Then, when hardenable sealing substance is transferred to the annular chamber 9 during inflation, some of the transferred hardenable sealing substance will flow past the support elements 53 and the locking pins 54, so that the hardenable sealing substance urges the flange 52 and the compression spring 23 downwards within the annular chamber 25 to charge the accumulator. The displacement of the flange 52 downwards in the annular chamber 25, results in the locking pins 54, which were pressed, prior to the displacement, by the flange 52 into locking engagement with the groove 55, being disengaged from the groove 55 of the housing sleeve element 51. Thereby the

packer element 8 may pull the housing sleeve element 51 along during the inflating. In a transition zone between the lower housing element 50 and the upper housing sleeve element 51 the respective element is formed with recesses 56, 57 adapted to one another.

In the set of figures the releasable and displaceable housing element 7, or the fixed housing element 30 with the annular piston 31, is positioned above the fixed housing elements 5, 6; 50, 51. Of course, this does not prevent the housing elements 7; 30 first mentioned, from being positioned below the housing elements 5; 6; 50, 51 last mentioned. In that case, the housing elements 5, 6; 50, 51 last mentioned must change places. Neither is there anything to prevent the releasable and displaceable housing element 7, or the fixed housing element with the annular piston 31, from being formed with more housing element chambers than the housing element chambers 10, 11, 12 shown. The condition is only that there shall be more chambers for the hardenable sealing substance than chambers for the well fluid supplied, so that the mentioned pressure reduction is maintained in the hardenable sealing substance which is transferred to the annular chamber 9. Besides, it is obvious that the releasable and displaceable housing element 7, or the annular piston 31 within the fixed housing element 30, may be released from and displaced, or displaced, on the housing element 4 by means of a different suitable fluid than the well fluid mentioned, e.g. a hydraulic fluid, supplied from the surface in a suitable manner.